

TRANSMITTAL LETTER TO THE UNITED STATES

MAT-7886US

DESIGNATED/ELECTED OFFICE (DO/EO/US)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

CONCERNING A FILING UNDER 35 U.S.C. 371

To Be Assigned

09/463565

INTERNATIONAL APPLICATION NO.

PCT/JP99/02828

INTERNATIONAL FILING DATE

27 May 1999 (27.05.99)

PRIORITY DATE CLAIMED

28 May 1998 (28.05.98)

TITLE OF INVENTION

BATTERY PLATE AND BATTERY

APPLICANT(S) FOR DO/EO/US

Tatsuya Hashimoto; Hiroyuki Murai; Yorihiro Ohana; Hiroshi Matsuno; Hideya Asano

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. ☐ Other items or information:

~~09-05/2001 DEPTV:FE 00000131 100350 09463565~~~~02-FC-501 10-00 CH~~

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.463) 09/463565	INTERNATIONAL APPLICATION NO. PCT/JP99/02828	ATTORNEY'S DOCKET NUMBER MAT-7886US
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21. The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :					
<input checked="" type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$970.00					
<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$840.00					
<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$690.00					
<input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$670.00					
<input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$96.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$970.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				\$0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	7 - 20 =	0	x \$18.00	\$0.00	
Independent claims	3 - 3 =	0	x \$78.00	\$0.00	
Multiple Dependent Claims (check if applicable).			<input type="checkbox"/>	\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$970.00	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).				<input type="checkbox"/>	\$0.00
SUBTOTAL =				\$970.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).				\$0.00	
TOTAL NATIONAL FEE =				\$970.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).				<input type="checkbox"/>	\$0.00
TOTAL FEES ENCLOSED =				\$970.00	
				Amount to be refunded	\$
				charged	\$

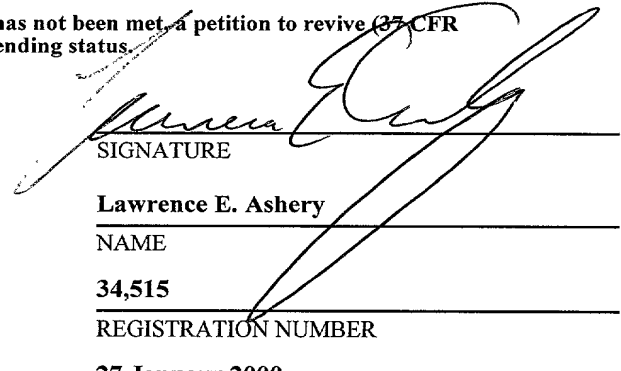
☒ A check in the amount of **\$970.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **18-0350** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Lawrence E. Ashery Ratner & Prestia P.O. Box 980 Valley Forge, PA 19482-0980	 SIGNATURE Lawrence E. Ashery NAME 34,515 REGISTRATION NUMBER 27 January 2000 DATE
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MAT-7886US

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	T. Hashimoto et al.	: Art Unit:
Serial No.:	09/463,565	: Examiner:
Filed:	Herewith	: Box PCT
FOR:	BATTERY PLATE AND BATTERY	:

SUPPLEMENTAL PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

S I R :

Prior to examination, please amend the above-identified application as follows:

IN THE CLAIMS:

Please amend claims 1-7 as follows:

- 1 1. (Amended) An electrode plate for a battery [characterized by using a
- 2 current collector], the electrode plate comprising a [to the] surface [of which]
- 3 having formed thereon an oxide layer, the oxide layer being formed by applying a
- 4 boehmite treatment [is applied, in at least one of the] to the electrode plate surface
- 5 [for positive electrode and electrode plate for negative electrode].
- 1 2. (Amended) [A battery using] The electrode plate as cited in Claim 1
- 2 wherein the electrode plate is included in the [the electrode plate for] battery [as
- 3 cited in Claim 1].

1 3. (Amended) The electrode plate [for battery] as cited in Claim 1,
2 wherein the oxide layer has a [the] thickness of [a thin coating formed on the
3 current collector surface by a boehmite treatment ranges from] 0.5 μm to 5 μm .

1 4. (Amended) The [battery] electrode plate as cited in Claim 2,
2 wherein the oxide layer has a [the] thickness of [a thin coating formed on the
3 current collector surface by a boehmite treatment ranges from] 0.5 μm to 5 μm .

1 5. (Amended) [An] The electrode plate [for battery characterized by
2 using a current collector, to the surface of which a boehmite treatment is applied, in

3 the positive electrode plate] as cited in Claim 1 wherein the electrode plate is
4 selected from the group consisting of a negative electrode plate and a positive
5 electrode plate.

1 6. (Amended) A [production] method for producing [of] a positive
2 electrode plate for a lithium secondary battery, the method comprising the steps of:
3 providing an electrode plate comprising a metallic foil;
4 forming a chrome oxide layer on [the surface of a current collector, which is

5 formed of a metallic foil,] the electrode plate by applying a chromate treatment
6 [thereto] to the electrode plate;
7 applying [a coating of] a paste [containing] comprising an electrode active
8 material to said [current collector] chrome oxide layer; and
9 drying the paste.

1 7. (Amended) [A lithium secondary battery using a] The method as
2 cited in Claim 6 wherein the positive electrode plate [that is produced according to
3 the production method as cited in Claim 6] is included in the lithium secondary
4 battery.

Please add the following new claims:

1 8. (Newly Added) The electrode plate as cited in Claim 1 further
2 comprising a paste formed on the oxide layer, the paste comprising an electrode
3 active material.

1 9. (Newly Added) The electrode plate as cited in Claim 8 wherein the
2 paste is a dried paste.

1 10. (Newly Added) A method for producing an electrode plate for a
2 lithium secondary battery, the method comprising the steps of:
3 providing an electrode plate;
4 forming an oxide layer on the electrode plate by applying a boehmite
5 treatment to the electrode plate;
6 applying a paste comprising an electrode active material to the oxide layer;
7 and
8 drying the paste.

REMARKS

Claims 1 through 7 have been amended to more clearly point out the inventive features of the present invention. In addition, claims 8-10 have been added. The addition of claims 8-10 is supported by originally filed claim 1, and in the specification at page 2, lines 17-25. No new matter is added.

Respectfully submitted,

RATNER & PRESTIA

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The Assistant Commissioner for Patents is hereby authorized to charge payment to Deposit Account No. 18-0350 of any fees associated with this communication.

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Assistant Commissioner for Patents, Washington, D.C.
20231 on:

April 10, 2000
Lawrence E. Ashery

420 Rec'd PCT/PTO 27 JAN 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: T. Hashimoto : Art Unit: To Be Assigned
Serial No.: To Be Assigned : Examiner: To Be Assigned
Filed: Herewith :
FOR: BATTERY PLATE AND :
BATTERY

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
S I R :

Prior to examination, please amend the above application as follows:

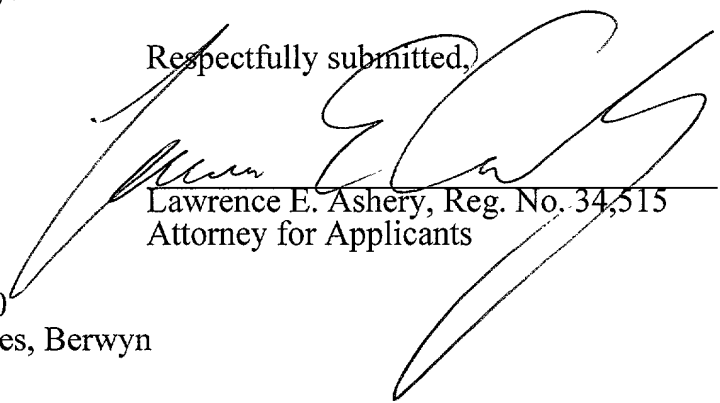
IN THE SPECIFICATION:

After the title and before the first paragraph, please insert --THIS APPLICATION IS A U.S. NATIONAL PHASE APPLICATION OF PCT INTERNATIONAL APPLICATION PCT/JP99/02828--.

IN THE DRAWINGS:

Please delete page "3/3" of the drawings, also labeled as "Reference Numerals" in its entirety.

Respectfully submitted,


Lawrence E. Ashery, Reg. No. 34,515
Attorney for Applicants

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Dated: January 27, 2000
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Date of Deposit: January 27, 2000

I hereby certify that this paper and fee are being deposited, under 37 C.F.R. § 1.10 and with sufficient postage, using the "Express Mail Post Office to Addressee" service of the United States Postal Service on the date indicated above and that the deposit is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.


Kathleen Libby

420 Rec'd PCT/PTO 27 JAN 2000

SPECIFICATION

BATTERY PLATE AND BATTERY

5

FIELD OF THE INVENTION

The present invention relates to improvements in electrode plates for battery and a battery using the improved electrode plates for battery.

BACKGROUND OF THE INVENTION

10

In order to prevent falling of an active material off a current collector of a battery due to *ENG.* discharge operations or during the assembly work *TRAPS.* of a chromate treatment or a corona discharge treatment *OF IUTL* the current collector has so far been proposed. (T *APP* aminated Publication Nos. S56-

15

57261 and H7-130000, the manufacturing of electrode plates for a lithium-ion secondary battery, a method of performing dispersion by kneading under the presence of a surface-active agent is disclosed as the method for improving the wettability of an active material against a bonding agent and a viscosity improver. (The Japanese Patent Unexamined Publication No. H8-190912)

20

However, it is found difficult for the foregoing electrode plates for battery to achieve an improvement in wettability of an active material against a bonding agent and a viscosity improver and also to satisfy the required adhesiveness between a current collector and an active material after the active material has been applied to the current collector. As a result, after a storage under high temperatures or during repeated charge/discharge operations, the active material peels and falls off the current collector, thereby causing the problem of a reduction in charge/discharge capacity.

25

30

The present invention deals with the foregoing unsettled problem to realize a lithium-ion secondary battery which shows minimal corrosion of a current collector due to an active material, minimal peeling and falling of the

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active material off the current collector, thereby demonstrating large discharge capacity.

DISCLOSURE OF THE INVENTION

5 The present invention deals with the afore-mentioned problem to provide an electrode plate for battery and a battery using it, the electrode plate for battery being characterized by applying a boehmite treatment to the surface of a current collector prior to an application of a paste, which is formed of a composition with an active material acting as the principal ingredient, to
10 the current collector.

With a method for producing electrode plates for lithium secondary battery characterized by applying a paste containing a positive electrode active material to a current collector formed of a metallic foil and then drying the paste, the current collector is applied with a chromate treatment on the
15 surface thereof to form a chrome oxide layer prior to the foregoing application of the paste.

The present invention discloses a method for producing electrode plates, the method comprising the steps of:
applying a boehmite treatment to the surface of current collector of one electrode plate selected from a positive electrode plate and a negative electrode plate or applying a chromate treatment to the surface of a positive electrode current collector;
applying a paste formed of a composition containing an electrode active material on the current collector; and
25 drying the paste.

Even when a battery employing the electrodes as described in the above is in usage with repeated charge/discharge operations, a reduction in the charge/discharge capacity and degradation in the load characteristics can be suppressed to a minimum.

30

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of a battery in an exemplary embodiment.

ment of the present invention.

Fig. 2 is a diagram to show cycle life characteristics by making a comparison between a prior art battery and a battery in an exemplary embodiment of the present invention.

5 Fig. 3 is a diagram to show cycle life characteristics by making a comparison between a prior art battery and a battery in another exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

10 Next, a description is given to a case where a boehmite treatment is applied to a positive electrode current collector for lithium-ion battery in an exemplary embodiment of the present invention.

(First Exemplary Embodiment)

15 A lithium-ion secondary battery in an exemplary embodiment of the present invention is a cylindrical lithium-ion secondary battery as shown in Fig. 1 and formed of a group of electrode plates produced according to the method as disclosed by the present invention, an electrolyte and a battery case 4 accommodating the foregoing. The group of electrode plates includes a sheet like electrode plate 1 for positive electrode, a sheet like electrode plate 2
20 for negative electrode, a sheet like separator 3 insulating the electrode plate 1 for positive electrode from the electrode plate 2 for negative electrode, a positive electrode lead 7, a negative electrode lead 8, an upper insulating plate 9 and a lower insulating plate 10. The separator 3 is a porous polyethylene film. All of the foregoing elements are superimposed one over another,
25 wound in a spiral fashion and placed inside the cylindrical battery case 4.

The battery case 4 is prepared by applying a deep drawing process to a stainless steel sheet having resistance to an organic electrolyte. After the group of electrode plates and electrolyte have been placed inside the battery case 4, the opening of the battery case 4 is closed by sealing with a
30 sealing plate 5 and a gasket 6 that acts as an insulator and also applies gas sealing between the sealing plate 5 and the battery case 4.

Now, a description is given to a boehmite treatment.

After a 30 μm thick aluminum foil acting as a positive electrode current collector has been immersed in a 12 cc/l solution of triethanolamine, an oxide film is formed by drying the foregoing aluminum foil for 4 hours at 100 °C to have the surface of the aluminum foil reformed. At this time, the thickness of the oxide film is preferred to be 0.5 to 5.0 μm . When the thickness of the oxide film is smaller than 0.5 μm , a sufficient effect of reforming the surface of the aluminum foil is not allowed to be realized, resulting in not so excellent adhesion with an active material. On the other hand, when the thickness of the oxide film exceeds 5.0 μm , the amount of the active material, which is allowed to be contained in the given same size of the battery case 4, is reduced, resulting in an excessive reduction of the battery capacity to cause an unacceptably large adverse effect.

Next, a description is given to a method for producing the electrode plate 1 for positive electrode. A paste formed of composition with an active material for positive electrode serving as the principal ingredient is prepared by mixing/dispersing 50 weight parts LiCoO_2 powder as the positive electrode active material, 1.5 weight parts acetylene black as a conductive agent, 7 weight parts aqueous solution of 50 weight parts PTFE as a binder and 41.5 weight parts aqueous solution of 1 weight part carboxymethylcellulose as a viscosity improver. The paste for positive electrode thus prepared is applied to both surfaces of the boehmite treated aluminum foil by using a die coater and, after the coated paste has been dried, the aluminum foil applied with the paste is heated to the melting temperature of PTFE ranging 200 °C to 300 °C, thereby further improving the adhesion between the current collector and the positive electrode composition layer. Then, the aluminum foil is rolled to a thickness of 0.18 mm and cut to produce the sheet like electrode plate 1 for positive electrode of the present invention.

A description is given to a method for producing the electrode plate 2 for negative electrode. A paste for negative electrode is prepared by mixing/dispersing 50 weight parts powder of scale like graphite particles acting as the negative active material, 45 weight parts aqueous solution prepared by dissolving 1 weight part carboxymethylcellulose in 99 weight parts water to

form a viscosity improver and 5 weight parts styrene-butadiene-rubber as a binder. The paste thus prepared is applied to a 40 μm thick copper foil by using a die coater to produce the electrode plate 2 for negative electrode.

The electrolyte is prepared by dissolving LiPF_6 in a mixed solution of
 5 30 vol% ethylene carbonate, 50 vol% diethyl carbonate and 20 vol% methyl propionate to a concentration of 1 mol / l. This electrolyte is contained inside the battery case, in which the positive electrode active material layer and negative electrode active material layer are impregnated with the electrolyte, thereby causing a cell reaction to take place with the electrolyte serving as a
 10 carrier of lithium ions between the electrode plate 1 for positive electrode and the electrode plate 2 for negative electrode by passing through minute holes of the porous separator 3.

A battery is prepared by using the foregoing electrode plate 1 for positive electrode and cycle characteristics of the battery are checked.
 15 The battery thus prepared measures 17 mm in diameter and 50 mm in height.

A battery for comparison, which is the same as the foregoing battery of the present invention except for using a positive electrode current collector with no boehmite treatment applied to the surface thereof, has been prepared to carry out a side-by-side performance evaluation.

20 The battery of the present invention and the battery for comparison are subjected to a cycle test, one cycle of which comprises the steps of constant current charging at 500 mA until the battery voltage reaches 4.1 V, switching to constant voltage charging when the battery voltage reaches 4.1 V, continuing the constant voltage charging until the total charging time reaches 2
 25 hours, starting discharging at 720 mA in an ambient temperature of 20 °C and suspending the discharging when the discharge voltage decreases to 3.0 V. Upon completing one cycle as above, the next cycle is started. Fig. 2 shows the results of the cycle test, i.e., cycle life characteristics, on the foregoing battery of the present invention and the battery for comparison with a capacity
 30 maintenance ratio indicated on the vertical axis and a number of cycles on the horizontal axis when charge/discharge operations as described in the above are repeated. It is found out from Fig. 2 that the battery of the present in-

vention shows little degradation in capacity after repeated charge/discharge operations when compared with the battery for comparison, thereby proving that the battery of the present invention has excellent cycle characteristics.

This is because of the needle like structure formed on the surface of the positive electrode current collector by an application of a boehmite treatment thereto and the enhanced adhesion between the current collector and the composition layer with the active material acting as the principal ingredient, the enhanced adhesion having been realized by the polymeric material of PTFE entangled with the needle like structure in a three-dimensional manner to demonstrate an anchor effect. Therefore, even when the composition layer containing the active material expands/shrinks due to repeated charge/discharge operations, it is hard for the composition layer to get separated from the current collector.

Also, the battery of the present invention and battery for comparison are kept in storage under a charged condition for 20 days at 60 °C and then subjected to several times of repeated charge/discharge operations at room temperature, followed with a discharging operation at 720 mA to find capacity till the time when the battery voltage reaches 3.0 V. The resulting capacity is compared with the capacity just before being kept in storage and Table 1 shows the findings.

Table 1

High Temperature Storage Characteristics	Battery of Present Invention	Battery for Comparison
(Capacity after Storage/ Capacity before Storage) × 100 (%)	98	93

As shown in Table 1, the battery of the present invention is found to show little degradation in capacity even under a high temperature storage condition.

A case, where the boehmite treatment is applied to the positive electrode current collector for a lithium secondary battery, is shown in the present exemplary embodiment but the boehmite treatment is also allowed to be applied to the negative electrode current collector for the same effect, and
5 further the same effect can be gained even when the boehmite treatment is applied to electrode plates of other battery systems.

(Second Exemplary Embodiment)

The preparation of an electrode plate 1 for positive electrode is made in the same way as in the first exemplary embodiment except for using an
10 aluminum foil, on the surface of which a chromium oxide layer is formed in advance by a chromate treatment, in place of an aluminum foil that is boehmite treated.

A paste for negative electrode used with an electrode plate 2 for negative electrode is prepared according to the same method as employed in
15 the first exemplary embodiment. The obtained paste for negative electrode is applied to both surfaces of a negative electrode current collector formed of a 50 μm thick copper foil by using a die coater and the applied paste is dried. Then, the copper foil is rolled to a thickness of 0.2 mm and cut to produce a sheet like electrode plate 2 for negative electrode.

20 An electrolyte, which is the same one as used in the first exemplary embodiment, is used in the present exemplary embodiment.

A battery is produced by using the foregoing electrode plate 1 for positive electrode in the same way as the first exemplary embodiment and the cycle characteristics of the battery are checked. The battery thus produced
25 measures 17 mm in diameter and 50 mm in height.

As a battery for comparison is used a lithium secondary battery prepared according to the same method as employed in the first exemplary embodiment except for using a positive electrode current collector without applying any chromate treatment to the surface thereof. Then, a comparison is
30 made between the battery for comparison of above and a lithium secondary battery using the positive electrode plate prepared according to the method of the present invention and the cycle characteristics of both batteries are as

shown in Fig. 3.

In the same way as in the first exemplary embodiment, the batteries are charged with a constant current of 500 mA and then, when the battery voltage has reached 4.1 V, charging of the batteries is switched to constant voltage charging, the constant voltage being 4.1 V, with the total charging time extended to as long as 2 hours. Discharging of the batteries is performed with a discharge current value of 720 mA at 20 °C and, when the discharge voltage has reached 3.0 V, the discharge cycle is ended and a new charge cycle is started. What is found out from Fig. 3 is that the lithium secondary battery using the electrode plate for positive electrode produced according to the method of the present invention shows little degradation in capacity in comparison with a lithium secondary battery using the electrode plate for positive electrode prepared according to the conventional method even when a charge/discharge operation is repeated, thus demonstrating excellent cycle characteristics.

This is because of the following reason. The battery using the electrode plate for positive electrode of a lithium secondary battery prepared according to the production method of the present invention shows a reduction in corrosion of the current collector caused by a composition layer since the composition layer with the principal ingredient thereof formed of an active material does not come into a direct contact with the current collector although the surface of the positive electrode current collector is chromate treated and the chromate treated coating on the surface of the current collector is corroded, and further since generation of hydrogen gas, which takes place in the vicinity of an interface between the two different substances at the time of corrosive reaction, can be suppressed, the adhesion between the positive electrode composition layer and the current collector is enhanced, thereby making it hard for the positive electrode composition layer to peel off from the current collector even if the positive electrode composition layer undergoes expansion/shrinkage due to charge/discharge operations of the battery.

In addition, when an aluminum foil is used to form the positive electrode current collector, the surface of the aluminum foil is corroded moder-

ately by the chromate treatment applied thereto, thereby enhancing markedly the adhesion of the positive electrode composition layer to the current collector because of the anchor effect created on the surface of the aluminum foil. On the other hand, when an iron foil is used to form the current collector, the anchor effect due to the chromate treatment is small.

Lithium secondary batteries prepared by the use of these electrode plates for positive electrode are kept in storage under a charged condition for 20 days at 60 °C, and then subjected to several times of repeated charge/discharge operations at room temperature, followed with a discharging operation at 720 mA to find capacity till the time when the battery voltage reaches 3.0 V. The resulting capacity is compared with the capacity just before being kept in storage and Table 2 shows the findings.

Table 2

High Temperature Storage Characteristics	Battery of Present Invention	Battery for Comparison
(Capacity after Storage/ Capacity before Storage) × 100 (%)	99	93

As shown in Table 2, a lithium secondary battery using an electrode plate for positive electrode prepared according to the production method of the present invention is found to show little degradation in capacity even under a high temperature storage condition.

INDUSTRIAL USABILITY

As described in the above, the present invention makes it possible for a secondary battery to suppress the degradation in charge/discharge capacity and storage characteristics to an extremely small extent when the battery is used in repeated charge/discharge operations.

In addition, even under such a stringent condition as the battery is in storage at high temperatures for a long period, the degradation in charge/discharge capacity can be suppressed to a minimum. Also, a composition layer formed of an active material acting as the principal ingredient thereof is prevented
5 from peeling off the current collector of an electrode plate during the assembly work of batteries, thereby enabling the enhancement of workability involved with the assembly work of the batteries.

2014 03 24 10 34 34

CLAIM

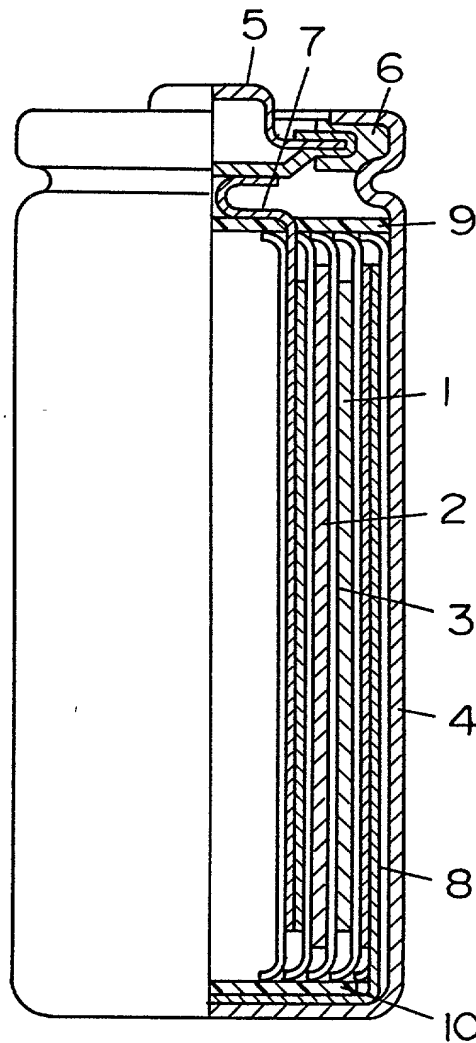
1. An electrode plate for battery characterized by using a current collector, to the surface of which a boehmite treatment is applied, in at least one of the electrode plate for positive electrode and electrode plate for negative
5 electrode.
2. A battery using the electrode plate for battery as cited in Claim 1.
3. The electrode plate for battery as cited in Claim 1, wherein the thickness of a thin coating formed on the current collector surface by a boehmite treatment ranges from 0.5 μm to 5 μm .
- 10 4. The battery as cited in Claim 2, wherein the thickness of a thin coating formed on the current collector surface by a boehmite treatment ranges from 0.5 μm to 5 μm .
5. An electrode plate for battery characterized by using a current collector, to the surface of which a boehmite treatment is applied, in the positive
15 electrode plate.
6. A production method of a positive electrode plate for lithium secondary battery, the method comprising the steps of:
forming a chrome oxide layer on the surface of a current collector, which is formed of a metallic foil, by applying a chromate treatment thereto;
20 applying a coating of a paste containing an electrode active material to said current collector; and
drying the paste.
7. A lithium secondary battery using a positive electrode plate that is produced according to the production method as cited in Claim 6.

ABSTRACT

5

Fig 1

1. Electrode Plate for Positive Electrode
2. Electrode Plate for Negative Electrode
3. Separator
4. Battery Case
5. Sealing Plate
6. Gasket
7. Positive Electrode Lead
8. Negative Electrode Lead
9. Upper Insulating Plate
10. Lower Insulating Plate



2/3

Fig 2

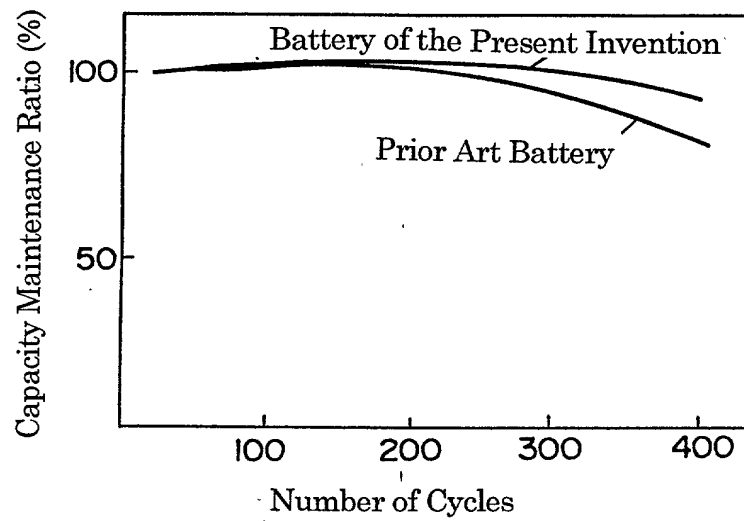
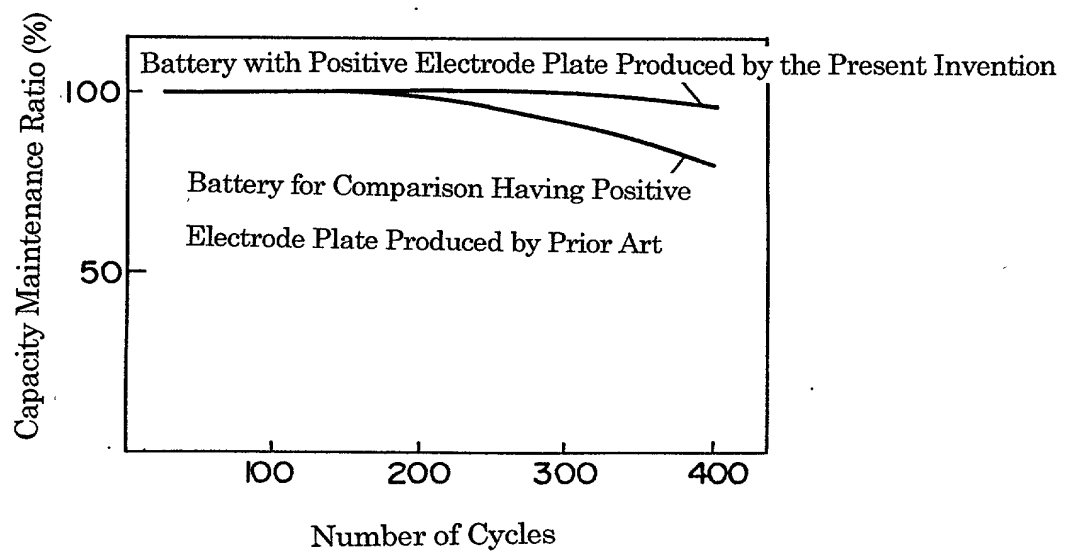


Fig 3



Key to Reference Numerals

1. Electrode Plate for Positive Electrode
2. Electrode Plate for Negative Electrode
3. Separator
4. Battery Case
5. Sealing Plate
6. Gasket
7. Positive Electrode Lead
8. Negative Electrode Lead
9. Upper Insulating Plate
10. Lower Insulating Plate

Declaration and Power of Attorney For Patent Application

English Language Declaration



As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

BATTERY PLATE AND BATTERY.

the specification of which is attached hereto unless the following box is checked:

☒ was filed on May 27, 1999 as

United States Application Number or PCT International Application Number PCT/JP99/02828

and was amended on January 27, 2000 (by preliminary amendment) (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Not Claimed

10-147117

Japan

28 May 1998

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

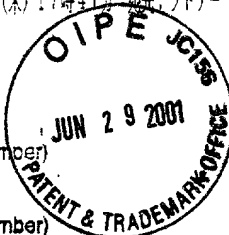
(Application Number)

(Filing Date)

(Application Number)

(Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:



(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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